

## **Module Title:** Limiting Reactants: The Key to Chemical Yield

### **Learning Objectives:**

- Students will be able to define limiting and excess reactants.
- Students will be able to predict the theoretical yield of a reaction based on the limiting reactant.
- Students will be able to use the PhET simulation to visualize and explore limiting reactant concepts.
- Students will be able to apply limiting reactant concepts to real-world scenarios and problems.

### **Materials:**

- PhET Simulation: "Reactants, Products, and Leftovers"
- Whiteboard or Projector
- Markers or Pens
- Worksheet (provided below)

### **Procedure:**

- 1. Introduction (10 minutes):**
  - Briefly review the concept of chemical reactions and stoichiometry.
  - Introduce the terms "limiting reactant" and "excess reactant."
  - Pose the question: "What happens when one reactant runs out before the others in a chemical reaction?"
- 2. PhET Simulation Exploration (20 minutes):**
  - Have students open the PhET simulation and familiarize themselves with the controls.
  - Guide students through a series of experiments within the simulation:
    - Start with a simple reaction (e.g., making sandwiches with bread and cheese).
    - Vary the amounts of each reactant to see how it affects the product and leftovers.
    - Introduce more complex reactions with different mole ratios.
  - Have students record their observations and answer questions on the worksheet.
- 3. Class Discussion (15 minutes):**
  - Facilitate a discussion about the simulation findings.
  - Use the whiteboard to illustrate the concept of limiting reactants using particle diagrams.
  - Connect the simulation to real-world examples (e.g., baking a cake, combustion reactions).
- 4. Worksheet and Problem-Solving (20 minutes):**
  - Have students work individually or in small groups to complete the worksheet, which includes:
    - Conceptual questions about limiting reactants.
    - Stoichiometry problems to calculate theoretical yield based on the limiting reactant.
    - Open-ended questions that require critical thinking and application of concepts.
- 5. Wrap-up (5 minutes):**
  - Summarize key takeaways from the module.
  - Address any remaining questions.
  - Assign additional practice problems for homework if desired.

### **Example Questions for the Worksheet:**

- **Conceptual:**
  - In your own words, explain what a limiting reactant is.
  - How does the limiting reactant determine the amount of product formed?
  - What happens to the excess reactant in a chemical reaction?
- **Stoichiometry:**
  - Given the balanced equation  $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ , if you have 5 moles of  $\text{H}_2$  and 3 moles of  $\text{O}_2$ , which is the limiting reactant? What is the theoretical yield of water?
  - A reaction requires 3 moles of A and 2 moles of B to produce 1 mole of C. If you have 12 moles of A and 7 moles of B, how much C can you produce?
- **Open-ended:**
  - Describe a real-world scenario where understanding limiting reactants is important.
  - Design an experiment using the PhET simulation to test a hypothesis about limiting reactants.

### How to Improve the Prompt:

Your initial prompt was already quite good. Here are a few minor tweaks:

- **Specify the PhET Simulation:** Instead of just saying "PhET simulation," be more specific and mention the title "Reactants, Products, and Leftovers."
- **Focus on Inquiry:** Emphasize the use of open-ended questions and encourage students to explore and discover the concepts themselves.
- **Real-world Examples:** Ask for more real-world examples to help students connect the theory to practical applications.

Let me know if you'd like a more detailed worksheet or additional examples!